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TRACKING OF MISSILES AND SPACE VEHICLES

REVIEW OF SOVIET LITERATURE

AID Work Assignment No. 12

Report 16

Aerospace Information Division

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Aerospace Information Division

SUBJECT: Monthly Report - AID Work Assignment No. 12

PERIOD : December 1961 to January 1962

This is the sixteenth in a monthly report series reviewing Soviet developments in tracking missiles and space vehicles. It is based on source materials received at the Aerospace Information Division from December 1961 through January 1962. Beginning with this issue the reports will appear quarterly. Information not directly related to the assigned subject has been included because of its broad implications for study in this field.

The materials in this report deal with the following topics:

I. Electromagnetic problems
II. Ion clouds and ionosphere perturbations
V. Radio astronomy

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TOPIC I. ELECTROMAGNETIC PROBLEMS

1) Borodin, A.V., P.P. Gavrin, I.A. Kovan, B.I. Petrushev, S.L. Nedoseyev, V.D. Rusanov, and D.A. Frank-Kamenetskiy. Magnetoacoustic oscillations and induction pinch instability. Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 2(8), Aug 1961, 317-321. QC1.Z47, v. 41

In a study of the behavior of an induction pinch rapidly compressed by radial oscillation, experimental equipment similar to that which is generally used for plasma induction compression and heating was employed under the following operating conditions: 1) a basic magnetic-field amplitude of 25 koe at a frequency of 59 kc; 2) a radio-frequency magnetic-field amplitude of 50 to 70 oe at a frequency of 50 mc; and 3) a vacuum of 10^{-1} to 10^{-3} mm Hg maintained in a quartz discharge tube containing air, hydrogen, argon, xenon, or helium. An СФР-2М high-speed photorecorder was used for recording the observations.

The study showed that quick radial compression of plasma generates in the plasma a natural audio-frequency magnetic oscillation which is damped with time. Ejection of longitudinal plasma "horns", thought to be the result of inertial instability, was observed at the moment of maximum plasma compression. The experimental data on the relationship between natural plasma oscillation and the mass of the gas are in good agreement with theoretical calculations.

2) Ponomarev, Ye.A. Some problems of L-F wave propagation in a pinched viscous plasma along a magnetic field. Astronomicheskiy zhurnal, v. 38, no. 5, Sep-Oct 1961, 877-884. QB1.A47, v. 38

In a study of the fading and interaction of various types of oscillations related to the heating of the solar corona, the theory of magnetohydrodynamic corona heating, "in spite of some difficulties", is considered the only acceptable theory, because it provides a satisfactory explanation of a number of phenomena. This theory can, in many cases, be brought into agreement with observational results by systematically taking into account the effect of viscosity. This possibility is illustrated by the consideration of a plane wave propagating in the direction of a magnetic field in a pinched viscous plasma and having an amplitude lower than the magnetic-field intensity. The fluctuation of the plasma density is considered to be lower than the density fluctuation of unperturbed plasma, and the effects of radiation and heat conductivity are ignored.

Relationships generalizing the known magnetohydrodynamic equations are derived and the following conclusions reached: 1) in a pinched viscous plasma the following waves may propagate along the magnetic field, depending on $V_0^2/\omega\theta$ where V_0 and ω are the wave velocity and wave frequency, respectively, and $\theta = c^2/4\pi\sigma + v$ (σ is the plasma conductivity and v the viscosity): magnetohydrodynamic and sound waves if $V_0^2/\omega\theta > 1$; and viscous, sound, and radio waves if $V_0^2/\omega\theta < 1$; 2) in relation to a magnetohydrodynamic wave, viscous plasma is a dispersing medium; 3) at $V_0^2/\omega\theta > 1$ the attenuation is

$$\delta = \frac{\omega^2 \theta}{2 V_0^3}\left(1 - \frac{c^2 V \omega^2}{2 \pi \sigma V_0^4}\right);$$

4) the attenuation of magnetohydrodynamic waves in plasma cannot be of unlimited low value and the concept of undamped waves cannot be regarded as correct when applied to solar conditions; 5) magnetohydrodynamic waves cause the appearance of strongly damped longitudinal waves which, under certain conditions, dissipate a considerable amount of energy; and 6) in high-conductivity plasma, the depth of penetration of viscous waves may exceed considerably the depth of penetration of electromagnetic waves, although the former carry only an insignificant amount of energy. (Department of Astronomy, Kiyev State University)

3) Silin, V.P. On the theory of electromagnetic fluctuations in a plasma. Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 41, no. 3(9), Sep 1961, 969-976.

V.P. Silin, in referring to previous studies in which the tensor of the complex dielectric constant was used in developing a theory of thermal fluctuations in an equilibrium plasma, points out that such a theory cannot be used for describing fluctuations in a rarefied plasma which is in a state of nonequilibrium. Noting that the plasma consists of a system of particles with weak interaction, Silin considers the following two cases: 1) the absence of a strong magnetic field, in which case the state of the particles can be described by plane waves; and 2) the presence of a strong field acting on the plasma, i.e., a case in which nonrelativistic treatment may be used and where spin effects may be disregarded. Expressions describing electromagnetic fluctuations in the plasma are derived on the basis of the electric-field operator. These expressions may also be used in determining fluctuations for cases in which the distribution of plasma particles is a function of coordinates and time. In the latter case, the correct description of fluctuations can be obtained only for frequencies and wave numbers larger than the characteristic frequencies and wave numbers which determine the variation of the nonequilibrium distribution function. (Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR)

4) Suprunenko, V.A., Ye.D. Volkov, N.I. Reva, Ye.A. Sukhomlin, P.Ya. Burchenko, and N.I. Rudnev. Investigation of pinch-effect dynamics in a magnetic field. Zhurnal tekhnicheskoy fiziki, v. 31, no. 10, Oct 1961, 1246-1247. QC1.Z48, v. 31

In a study of the pinch-effect dynamics in a magnetic field, a straight porcelain tube 18 cm in diameter and 42 cm in length, filled with hydrogen at a pressure of $1.5 \cdot 10^{-3}$ mm Hg, was used. A 15-μf capacitor bank was discharged through the tube. A pulse transformer was employed for matching the high-voltage battery with the discharge tube. A glass tube containing a system of 9 magnetic probes was placed inside the discharge tube; the discharge period varied from 30 to 60 μsec. The processing of magnetic-probe signals made it possible to ascertain not only the position of the discharge in the chamber, but its conductivity, current density, and electric-field intensity at any given moment and at any given point. It was found that the amplitude of discharge oscillations along the discharge chamber increased proportionally to the square root of the electric-field intensity.

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TOPIC II. ION CLOUDS AND IONOSPHERE PERTURBATIONS

1) Gusev, V.D., and Yu.V. Berezin. Measurement of radio-wave absorption in the presence of large ionospheric inhomogeneities. IN: Moscow. Universitet. Vestnik. Seriya III: Fizika, astronomiya, no. 5, Sep-Oct 1961, 39-47.

A possible method is discussed for reducing the effect of large ionospheric heterogeneities on the amplitude and phase of radio waves reflected from the ionosphere. In order to demonstrate that under certain conditions the amplitudes of signals reflected from the ionosphere are subject to focusing effects, an equation for the amplitude of the reflected wave was derived on the basis of an approximation of geometrical optics under the assumption that the reflecting surface represents the real ionosphere. A statistical analysis was made of the influence of large heterogeneities on the phase of a reflected signal. It was concluded that, in order to avoid serious errors in measuring the coefficient of reflection, the focusing effects to which the reflected waves are subject must be taken into account and the measured values of the coefficient should be averaged within a time interval whose length depends on the parameters of the reflecting layer. For the F layer this interval is about one hour. (Department of Radio-Wave Propagation, Moscow State University)

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TOPIC V. RADIO ASTRONOMY

1) Koshchenko, V.N., B.Ya. Losovskiy, and A. Ye. Salomonovich. Lunar radio emission on the 3.2-cm wavelength. Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika, v. 4, no. 4, 1961, 596-599. QC661.R8, v. 4

The Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR, has measured the two-dimensional distribution of lunar brightness on the 3.2-cm wavelength with the aid of a 22-m radio telescope. The antenna beam width at the 3-db level was 6.3' (±0.2'). A conventional modulated radiometer whose threshold sensitivity was 3 to 4° with a time constant of 1 sec served as a receiver. The following approximate expression for the variation of the temperature at the center of the lunar disk with the phase of the moon Φ was derived on the basis of the results obtained:

$$T = 223 - 17 \cos (\Phi - 45^\circ).$$

The relative error in temperature measurement was ± 5%, while the absolute error resulting from an approximate determination of antenna parameters was ± 15%. The error in determining the lag between the radio phase and the optical lunar phase was ± 5%. The temperature deviation from the average value was determined to be ± 7.5% and the depth of penetration of radio and thermal waves for the 3.2-cm wavelength, 6.1 cm. The latter value agrees closely with that obtained on the 2-cm wavelength. The experimental phase lag (45 ± 5°) in the expression for the temperature also agrees closely with the value of 41° obtained analytically for a model of a homogeneous radiating layer. (Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR)

2) Krotikov, V.D., V.A. Porfir'yev, and V.S. Troitskiy. Calibration of lunar radio emission on the 3.2-cm wavelength. Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika, v. 4, no. 4, 1961, 759. QC661.R8, v. 4

The Scientific Research Institute of Radiophysics, Gor'kiy University, has developed a new method for the accurate measurement of radio emission of the moon and discrete radio emission sources in the centimeter wavelength range. The method involves the comparing of lunar radio emission with the thermal emission of two standards. This method was used experimentally in measuring lunar radio emission on the 3.2-cm wavelength. A radiometer with a threshold sensitivity of 0.2°K and a time constant of 16 sec served as a receiver. The antenna beam width was 1.3°. An absolutely black disk of visible angular dimensions commensurate with those of the moon was used as the first standard, while a black plane with an opening equal in size to the disk served as the second standard. Both were placed 15 to 20° above the horizon. The following expression for the average lunar radio temperature on the 3.2-cm wavelength as a function of the lunar phase Ωt was obtained: $T = 210 + 13.5 \cos(\Omega t - 55°)$. The total systematic error of measurement did not exceed ± 2.5%. It is suggested that the error can be reduced by a factor of at least 2. (Gor'kiy Scientific Research Institute of Radiophysics)

3) Kuz'min, A.D., and A.Ye. Salomonovich. Radio emission from the Taurus-A region on the 8-mm wavelength. IN: Akademiya nauk SSSR. Doklady, v. 140, no. 1, 1 Sep 1961, 81-83. AS262.S3663, v. 140

A series of observations of the Taurus-A radio-emission source was conducted by the Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR, during March and April of 1961. The observations were made on the 8-mm wavelength with the use of a 22-m radiotelescope. The sensitivity of the radiometer which served as a receiver was 1.5°K with a time constant of 5 sec. The experimental recording of the radio emission from the Taurus-A region showed the presence of a second maximum point separated by 36 sec from the maximum point which represents the position of the Taurus-A source. It is suggested that the second maximum may represent a previously unidentified source of radio emission. The antenna temperature of this source was found to be 2.8°K (± 10%); the brightness temperature, 7°K (± 25%); and the emission flux density, $130 \cdot 10^{-26}$ ω/m²cps (± 25%). The mean value of the antenna temperature of the Taurus-A source was determined to be 4.5°K (± 10%); the brightness temperature, 6°K (± 10%); and the emission flux density $500 \cdot 10^{-26}$ ω/m² . cps (± 2.5%). (Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR)

4) Salomonovich, A.Ye., and V.N. Koshchenko. Observations of lunar thermal radio emission on the 2-cm wavelength. Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika, v. 4, no. 4, 1961, 591-595. QC661.R8, v. 4

The Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR, conducted observations of lunar radio emission on the 2-cm wavelength with the aid of a 22-m radio telescope during November and December 1959. A conventional modulated radiometer served as a receiver, and a circular waveguide was used as an exciter. The electrical vector of the linearly polarized waves received formed a 45° angle with the plane of the horizon. The antenna beam-width at the 3-db level was a little over 4' in both the E and H planes. From eleven measurements taken the following expression for lunar-brightness temperature as a function of the phase of the moon was obtained: $T = 190 - \cos(\Phi - 40°)$, where Φ is the phase angle of the moon. Under the assumption that the distribution of the lunar surface temperature is described by the function $\sqrt{\cos}(\varphi)$, φ being the lunar latitude, and that the surface temperature at the center of the moon at lunar midday is 407°K and at midnight 125°K, the depth of penetration of 2-cm waves was determined to be 4.4 cm. The systematic error in determining the lunar brightness was about ± 15%. (Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR)

5) Vitkevich, V.V., A.D. Kuz'min, L.I. Matveyenko, P.L. Sorochenko, and V.A. Udal'tsov. Radioastronomical observations of Soviet space rockets. Radiotekhnika i elektronika, v. 6, no. 9, Sep 1961, 1420-1431. TK7800.R4, v. 6

A specially designed radio interferometer with phase modulation is being used, along with other devices, for tracking Soviet space rockets equipped with 183.6-mc transmitters. The antenna system consists of two truncated parabolic reflectors 8 x 18 m and 11 x 12 m, placed 176 m apart, with focal lengths of 8m. A specially designed antenna exciter system with a 0.75-0.8 traveling-wave ratio is placed at the focal point of each of the parabolic reflectors. The sensitivity of the interferometer makes it possible to receive signals from a 0.03-ω transmitter at a distance equal to the lunar distance and insures 1-2' accuracy in angular measurement. The three Soviet space rockets, launched 2 Jan, 12 Sep, and 14 Oct, 1959, were tracked with the aid of this interferometer. Examples from recorded signals from Lunik II are given. (Physics Institute imeni P.N. Lebedev, Academy of Sciences USSR)

6) Yesepkina, N.A., N.L. Kaydanovskiy, B.G. Kuznetsov, G.V. Kuznetsova, and S.E. Khaykin. Investigation of radiation characteristics of pencil-beam image antennas with reflectors of variable cross section. Radiotekhnika i elektronika, v. 6, no. 12, Dec 1961, 1947-1960. TK7800.R4, v. 6

The radiation pattern of antennas with reflectors of variable cross section is determined on the basis of both the field value of the cophased aperture of the antenna and the electric currents in the reflector. Emphasis is given to the antenna field of the frontal half-space, since the side and back radiation is of approximately the same structure as that in usual parabolic antennas. Calculations were made which were based on the fact that the reflector of the antenna investigated converts a plane wave into a cylindrical wave with a vertical generatrix (and vice-versa), and that any linear exciter placed at the focal point of the reflector can focus a converging cylindrical wave into one point. These calculations showed that the radiation pattern changes in the vertical plane with elevation without affecting the antenna gain. The method of geometric optics was applied to determine the field of the aperture. It was shown that under vertical polarization of the exciter field, the field in the aperture is directed along the radius from the center of the aperture, while under horizontal polarization of the exciter field it is directed along the line tangent to the circumference of the aperture. The change of the horizontal pattern with the variation in elevation was shown to be dependent on the horizontal dimension of the antenna and occurs only at a constant irradiation angle. The utilization factor does not increase as a result of the narrowing of the vertical radiation pattern. It was also shown that the variation of the utilization factor with elevation is slight.

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